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LAUNCH MISSION SUMMARY AND SEQUENCE OF EVENTS

SBS-A

DELTA-153

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15. Abstract

This document contains a brief summary of the launch vehicle, spacecraft, and mission. Also included is information relative to launch windows, vehicle telemetry coverage, realtime data flow, telemetry coverage by station, selected trajectory information, and a brief sequence of flight events.

16. Key Words

Launch vehicle, spacecraft, mission, launch windows, telemetry, data flow, trajectory, and flight events.

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LAUNCH MISSION SUMMARY AND TERMINAL COUNTDOWN

DELTA-153

SATELLITE BUSINESS SYSTEMS SATELLITE

(SBS-A)

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SBS-A SPACECRAFT DESCRIPTION

The first of three synchronous altitude, geostationary spacecraft, in a new satellite system that will further the use of outer space for business communications, will be launched on board a two-stage Delta-3910 launch vehicle from NASA Launch Complex 17, Pad-A, on the Cape Canaveral Air Force Station. The Delta will place the Satellite Business Systems spacecraft (SBS-A) into a low impact orbit, with an apogee of 173 statute miles (278 kilometers).

A new solid propellant motor assembly called the Payload Assist Module (PAM) will be used to raise the SBS-A from the low impact orbit into an elliptical transfer orbit with an apogee of 22,934 statute miles (36,908 kilometers) and a perigee of 104 statute miles (167 kilometers), at an inclination to the equator of 27.7 degrees. The PAM, conceived and built by the McDonnell Douglas Astronautics Company, comprises three major elements; a payload attach fitting, a Thiokol developed solid rocket motor, and a spin table. The solid rocket motor has a burn time of approximately 85 seconds at an average thrust of 19,000 pounds. A S&A device for the PAM is located on the payload attach fitting. After the solid rocket motor has completed firing, the entire assembly is separated and ejected from the spacecraft.

SBS-A, designed and built by Hughes Aircraft Company, is expected to have a life span of 7 years. It is owned and will be operated by Satellite Business Systems (SBS), a partnership sponsored by Aetna Life & Casualty, COMSAT General Corporation, and IBM.

Spacecraft flight controllers at the COMSAT Launch Control Center in Washington, D.C., will assume control of SBS-A in the elliptical orbit. After tracking the spacecraft to determine its flight path, the flight controllers will correctly orient the spacecraft, and at apogee of the fourth orbit fire an on-board solid propellant Apogee Kick Motor (AKM). This final burn will place the spacecraft into a near-geosynchronous orbit. Using the INTELSAT chain of ground stations located at various sites around the world, the COMSAT controllers will track and control the spacecraft until it reaches its final position at 106 degrees west longitude, approximately south of Santa Fe, New Mexico. The controllers will then fire the on-board hydrazine-powered reaction control system thrusters to stop the drift motion and position SBS-A in geosynchronous orbit at an altitude of 22,250 miles (35,803 kilometers) and a speed of 6,876 miles (11,066 kilometers) per hour. At that altitude and velocity its movement becomes sychronized with that of the earth so that it appears to remain stationary, but actually completes one orbit every 24 hours.

After the satellite has arrived at its permanent location at 106 degrees west longitude, the SBS Tracking, Telemetry, and Command (TT&C) facilities, consisting of a beacon station at Castle Rock, Colorado, and a control station at Clarksburg, Maryland, will assume control of the TT&C functions.

SBS-A represents a new entry in the rapidly growing field of satellite communications from geosynchronous orbit. The customers served by SBS will be primarily from the business community, rather than the public at large. SBS is currently installing earth stations on the premises of several customers, and will begin providing commercial private-network services in January. These services are available to businesses, government agencies, public-service organizations, and other entities having a requirement for large volumes of communications traffic among widely dispersed operating locations in the contiguous 48 states.

Two main elements of the SBS spacecraft are the spinning rotor, comprising 70 percent of the on-station vehicle weight, and the despun earth-oriented platform containing the communication repeater and its antenna. A rotating interface, consisting of ball bearings and slip rings, permits signal transfers to take place and affords an electrical path over which power from the solar panels and batteries can flow to the repeater payload. The overall spacecraft length at launch is 111 in. (282 cm); its maximum diameter is 85.25 in. (216 cm). After antenna deployment and extension of one solar panel cylinder, the overall spacecraft length is 260 in. (660.4 cm).

The spinning structure is built around a central thrust tube composed of two frustrum cones, a cylinder, and five ring frames. The equipment shelf, attached to the thrust tube, is an aluminum honeycomb sandwich platform with aluminum facesheets. The despun compartment structure consists of a monocoque conical frustrum, annular and cylindrical honeycomb sandwich shelves, and a pair of bipods, which support the antenna assembly. All communication equipment is located on the despun shelf. Four polar mount propulsion tanks between eight radial support struts are connected by tubular bipod/tripod structures to the central cone.

The spinning equipment shelf, supported at and near its rim by eight struts, carries earth sensors, radial thrusters and batteries on the forward face and, on the aft face, the encoders, decoders, power control electronics, and attitude control equipment. Components also are mounted to the central thrust tube cone; these include the axial thrusters, the safe and arm unit, the spacecraft/PAM interface umbilical connectors, and the bus limiters. The solar array substrate is rigidly attached to the spinning shelf via eight shear bearing fittings which minimize local substrate deformation.

The spacecraft configuration uses a part of the solar panel drum as a dedicated, mirrored thermal radiator. Ninety percent of the spacecraft thermal dissipation is rejected by this radiator which provides a low temperature, highly stable heat sink for battery temperature control. A small annular radiator on the substrate forward end rejects equipment thermal dissipation in transfer orbit when the stowed aft panel covers the primary drum radiator. A low emittance despun thermal radiator barrier on the forward end helps stabilize equipment temperatures.

The communication subsystem receives signals at 14 GHz and transmits the same signals at 12 GHz. These signals are channelized by the input multiplexer, amplified and conducted to the transmit antenna through crossover switches and output miltiplexers. A total of 16 channels are utilized. Each channel is 43 MHz wide and will

accommodate either analog FM transmissions or digital transmissions. The reflectory antenna, with a diameter of 72 inches and a 60-inch focal length, is composed of two essentially independent offset grid reflectors which are superimposed in the same aperture. One is horizontally polarized (transmit); the other is vertically polarized (receive). The front horizontal grid reflector is essentially RF transparent to vertically polarized signals which are flected from the rear reflector. The transmit feed array consists of 10 feed horns fed by a power divider that distributes power in an appropriately weighted manner. The receive feed is compsed of 15 horns, eight of which are trifurcated to be equivalent to three smaller horns. Two C-band antennas will operate during the transfer orbit while the K-band antennas will function during synchronous orbit.

A combination of C- and K-band RF and digital hardware provides the SBS spacecraft with telemetry, command, and ranging capability. The telemetry subsystem has two identical links consisting of spinning and despun encoders modulating either of two C-band transmitters/two K-band transmitters via a cross-strap switch. The spinning/despun interface is provided by slip rings. Three types of data are available by telemetry: pulse code modulation (PCM), FM realtime, and FM nutation accelerometer.

The command subsystem contains a C-band omni antenna which feeds redundant C-band command receivers, while a K-band omni antenna and the communication antenna feed redundant K-band command/track receivers. The baseband outputs of the C- and K-band receivers are summed and the composite signal drives redundant despun and spinning decoder pairs. The decoders provide complete control for all spacecraft functions. Transfer orbit ranging capability is provided by commandable switching of either C-band command receiver output to either C-band telemetry transmitter. The alternate telemetry transmitter is available to provide full telemetry data.

The Attitude Control Subsystem (ACS) provides velocity control, spin axis attitude control and stabilization, and antenna pointing control throughout the spacecraft mission lifetime. Velocity maneuvers are executed by ground commanded thruster firings, while attitude maneuvers may be accomplished by either ground command or autonomous thruster pulsing. These maneuvers and the spin speed operating range are selected so that no additional spin control is required for a nominal mission, while positive spin control is provided if necessary. Data for ground attitude determination are supplied by spinning sun and earth sensors during transfer and drift orbits. An autonomous thruster-activated Active Nutation Control (ANC) assures rapid large-angle nutation damping at any time in the mission. Precision antenna pointing on-station is maintained by active tracking of the ground beacon in two axes.

The power subsystem, consisting of solar panels, batteries, power control electronics, and wiring harnesses, is designed to satisfy all spacecraft load requirements for the mission lifetime. Spacecraft power is provided by two independent and balanced electrical buses. During sunlight operation, all spacecraft loads receive power from the main solar arrays at 29.75 volts dc. During transfer orbit, the aft cylindrical solar panel, stowed over the fixed forward cylindrical solar panel, provides satellite power. In synchronous orbit, the aft panel

is extended to its normal position, and 914 watts of power is supplied by both solar panels. Two 32 cell, 21.6 A-hr nickel-cadmium batteries provide electrical energy during launch, transfer orbit, and solar eclipses. The batteries are on-line during sunlight operation to supplement the solar arrays in supplying power for fault clearing or transients. The batteries are charged by charge arrays connected between the main bus and the battery buses.

The Reaction Control Subsystem (RCS) performs satellite velocity and attitude control maneuvers in response to onboard and ground commands. When commanded, the thruster valve opens and hydrazine is pressure-fed to the thruster, which catalytically decomposes the hydrazine to produce thrust. The propellant is contained in two conispherical titanium alloy tanks per half subsystem. A cross-connect latch valve allows transfer of propellant between subsystem halves, making all propellant available to any thruster. Each half subsystem contains a squib valve in the gas manifold connecting the two tanks, preventing propellant migration when the tanks are at different heights during launch operations. There are two thrusters per half subsystem, one axial and one radial.

The AKM is a solid propellant rocket motor that consists of a titanium case made from two 30-inch diameter hemispheres separated by a cylindrical section. The motor mounting flange is attached to the aft hemisphere. The nozzle includes: a closure section containing the integral torodial igniter assembly and the throat; and the carbon—carbon nozzle exit cone externally insulated with carbon-felt material. The S&A device is remotely mounted from the motor and is connected to the igniters by two explosive transfer assemblies and through-bulkhead-initiators. The motor uses HTPB propellant with 89 percent solids.

DELTA LAUNCH VEHICLE

First launched by NASA in May 1960, the reliable Delta vehicle can be utilized in various combinations of stages and strap-on motors, sized to meet the particular requirements of individual missions. The Delta has been flown as a two- or three-stage vehicle, with zero, three, six, or nine Castor II or nine Castor IV solid propellant motors attached to the first stage. A Delta is now 116 feet (35.4 m) tall and 8 feet (2.4 m) in diameter (not including the solids). This vehicle has a gross weight of approximately 423,500 pounds (192,099 kg) at liftoff.

Stage I is a long-tank derivative of the Thor vehicle, measuring 74 feet (22.5 m) in length and 8 feet (2.4 m) in diameter. It is powered by a Rocketdyne RS-27 main engine system that burns RP-1 and liquid oxygen. The main engine, plus the two vernier engines, is rated at 207,000 pounds (920,777 N) of thrust at sea level, and has a burn time of approximately 228 seconds.

This vehicle utilizes nine Castor IV solid propellant strap-on motors for additional first stage thrust. A Castor IV is 36.9 feet (11.2 m) in length, 3.3 feet (1 m) in diameter, and weighs about 24,500 pounds (11,113 kg). Each motor delivers an average of 85,270 pounds (379,298 N) of thrust for 57 seconds. Five ignite at liftoff and four ignite after the first five burn out. Total first stage thrust averages 635,350 pounds (2,824,607 N) from liftoff to burnout of the five solids.

Stage II is approximately 21 feet (6.4 m) long and 55 inches (140 cm) in diameter. The TR-201 main engine, built by TRW, uses nitrogen tetroxide as the oxidizer and Aerozene-50 as the fuel. It produces 9,800 pounds (43,592 N) of thrust and can burn for over 300 seconds.

The second stage has an 8-foot (2.4 m) wide and 11-inch (28 cm) high structural assembly called the miniskirt attached 3.5 feet (1 m) from its top. This miniskirt rests on an 8-foot (2.4 m) diameter interstage barrel 15.5 feet (4.7 m) high, which extends upward from the top of the first stage. A 26-foot (7.9 m) high fairing sits on top of the miniskirt and completes the exterior view of the vehicle. The second stage hangs down inside the interstage and extends up into the fairing, protected from contact with the atmosphere during the first stage flight.

The Delta Redundant Inertial Measurement System (DRIMS), which controls the flight of the vehicle, is mounted in the second stage. It consists of an inertial sensor package and a digital guidance computer. The sensor package provides vehicle attitude and acceleration information to the guidance computer, which controls the sequence of operations. The guidance computer generates vehicle steering commands for Stages I and II. These steering commands correct trajectory deviations by comparing computed positions and velocities against established values. The computer also controls timing, staging, and engine restarts, including those for engineering experimental burns performed after the main mission. The PAM stage is held on a steady course by spinning motion, and requires no guidance.

SBS-A LAUNCH WINDOWS

Date	Open	Close	Duration (min.)	Open	Close	Duration (min.)	Open	Close	Duration (min.)
Nov. 6-7	EST 1744 GMT 2244	1851 2351	67	1926 0026	1937 0037	11	2013 0113	2032 0132	19
7-8	EST 1745 GMT 2245	1852 2352	67	1927 0027	1938 0038	11	2014 0114	2032 0132	18
8-9	EST 1745 GMT 2245	1852 2352	67	1927 0027	1939 0039	12	2015 0115	2031 0131	16
9-10	EST 1746 GMT 2246	1853 2353	67	1928 0028	1940 0040	12	2016 0116	2031 0131	15
10-11	EST 1746 GMT 2246	1854 2354	68	1929 0029	1940 0040	11	2016 0116	2031 0131	15
11-12	EST 1747 GMT 2247	1854 2354	67	1930 0030	1941 0041	11	2017 0117	2030 0130	13
12-13	EST 1747 GMT 2247	1855 2355	68	1930 0030	1942 0042	12	2018 0118	2030 0130	12
13-14	EST 1748 GMT 2248	1856 2356	68	1931 0031	1943 0043	12	2019 0119	2030 0130	11
14-15	EST 1748 GMT 2248	1856 2356	68	1932 0032	1943 0043	11	2020 0120	2030 0130	10
15-16	EST 1749 GMT 2249	1857 2357	68	1932 0032	1944 0044	12	2021 0121	2030 0130	9
16-17	EST 1749 GMT 2249	1858 2358	69	1933 0033	1945 0045	12	2021 0121	2029 0129	8
17-18	EST 1750 GMT 2250	1858 2358	68	1934 0034	1946 0046	12	2022 0122	2029 0129	7
18-19	EST 1751 GMT 2251	1859 2359	68	1935 0035	1946 0046	11	2023 0123	2029 0129	6
19-20	EST 1751 GMT 2251	1900 0000	69	1935 0035	1947 0047	12	2024 0124	2029 0129	5

SBS-A ANTICIPATED TELEMETRY COVERAGE

It is planned that Delta-153 telemetry data will be received by TEL-IV, Merritt Island Unified S-band Station (MIL), Antigua (ANT), Ascension - ETR (ASC), Ascension - STDN (ACN), and ARIA. Anticipated coverage times during powered flight are shown on page 12. The data flow is shown on page 11. Realtime data will consist of STDN 56 kbps format, special groups as shown on pages 9 and 10, the total data from Tel-IV, and special spacecraft circuits. This will be the first flight of the PAM-D stage, and it will have a typical stage III telemetry system. ARIA will send the 13.89 Kbit stage II PCM data via satellite, and 2.4 Kbit data via HF radio.

Antigua Retransmission

Transmit System	Vehicle VCO	Data
	High Freq Subcable	
80 khz VCO	2-G	PCM
	Low Freq Subcable	
VCO-C	2-E	PDM
-A	2-A	Triax Accelerometer, Thrust
-13	2-13	Engine Chamber Pressure
-12	2-12	Triaxial Accelerometer, Pitch
-11	2-11	Triax Accelerometer, Yaw
-10	3-17	Thrust Accelerometer
-9	3-16	Yaw Accelerometer
-8	2-8	Roll/Pitch Jet Actuation
-7	2-7	Pitch/Roll Jet Actuation
	Low Low Freq Subcable	
-6	2-6	Yaw Jet Actuation
-5	2-5	Control Battery Current
-4	3-15	Pitch Acceleration
-3	3-14	Low Level Accelerometer

Ascension ETR to AE/CIF

VCO	Vehicle VCO	Data
1	2G-4	Roll Attitude Error
2	2-8	Roll/Pitch Jets
3	2-7	Pitch/Roll Jets
4	2G-5	Pitch Attitude Error
5	3-14	Low Level Acceleration
6	3-16	Yaw Radial Accel
7	3-18	Motor Chamber Pressure
8	----	IPPS Time

Ascension STDN to AE/CIF Via STDN Comsat and GSFC

VCO	Vehicle VCO	Data
2	3-14	Low Level Acceleration
3	3-15	Pitch Acceleration
4	3-16	Yaw Acceleration
5	3-17	Thrust Acceleration
6	3-18	Motor Chamber Pressure
7	2-6	Spin Rate/Jaw Jets
8	----	Time

Ascension ETR to AE/CIF

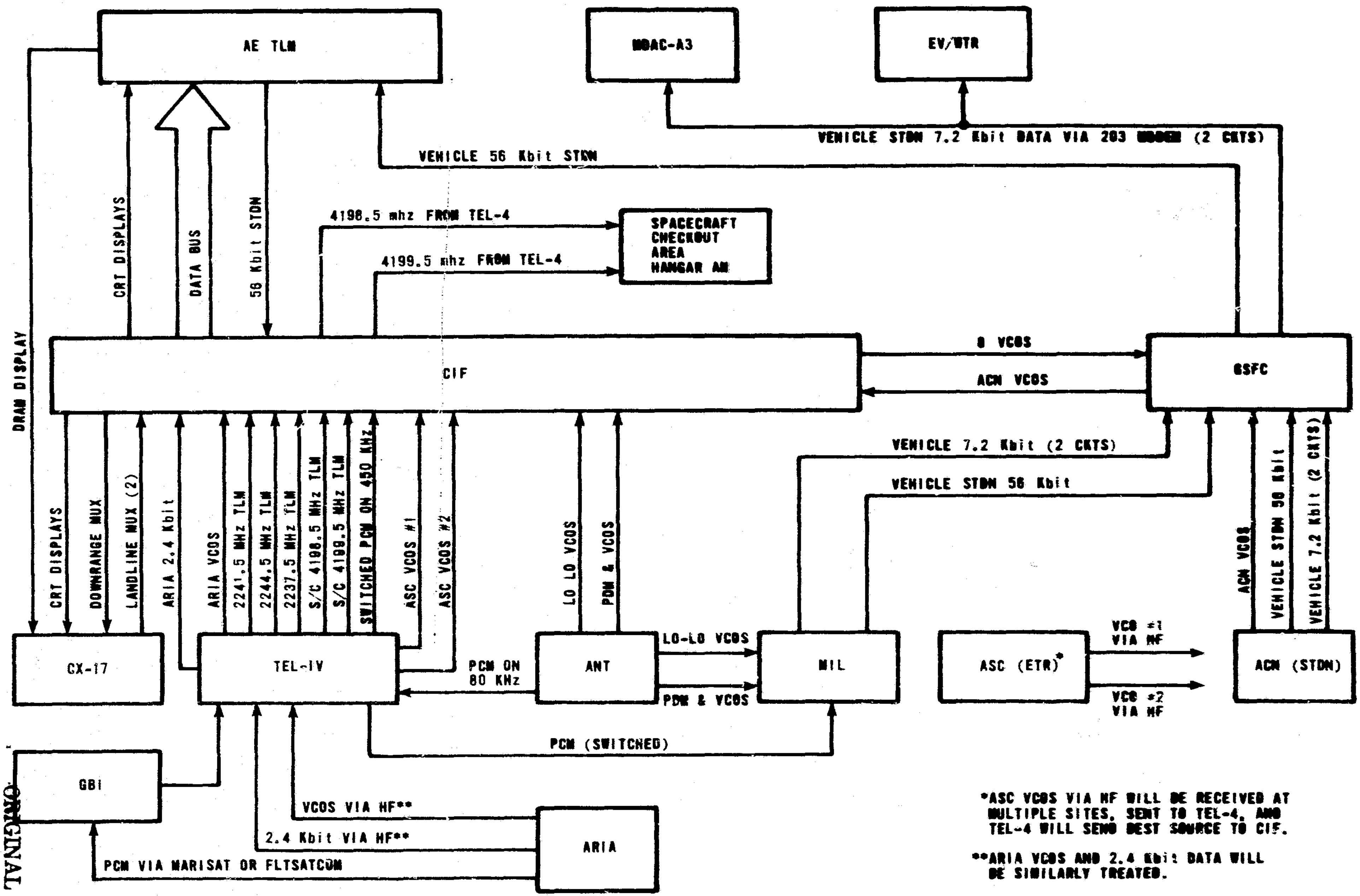
VCO	Vehicle VCO	Data
1	2E-20	Control Battery Voltage
2	2E-27	Nitrogen Reg Press
3	2G-6	Yaw Attitude Error
4	2-6	Yaw Jets
5	2E-38	Helium Reg Pressure
6	3-15	Pitch Radial Accel
7	3-17	Thrust Accel
8	----	Time

NOTE: All 2G channels to have a DAC shift of 3.

ARIA Retransmission

VCO	Vehicle VCO	Data
3	3-14	Low Level Accelerometer
4	3-15	Pitch Accelerometer
5	3-17	Thrust Accelerometer
6	3-18	Motor Chamber Pressure
7	2-6	Spin Rate/Yaw Jets

SBS-A REALTIME TELEMETRY DATA FLOW

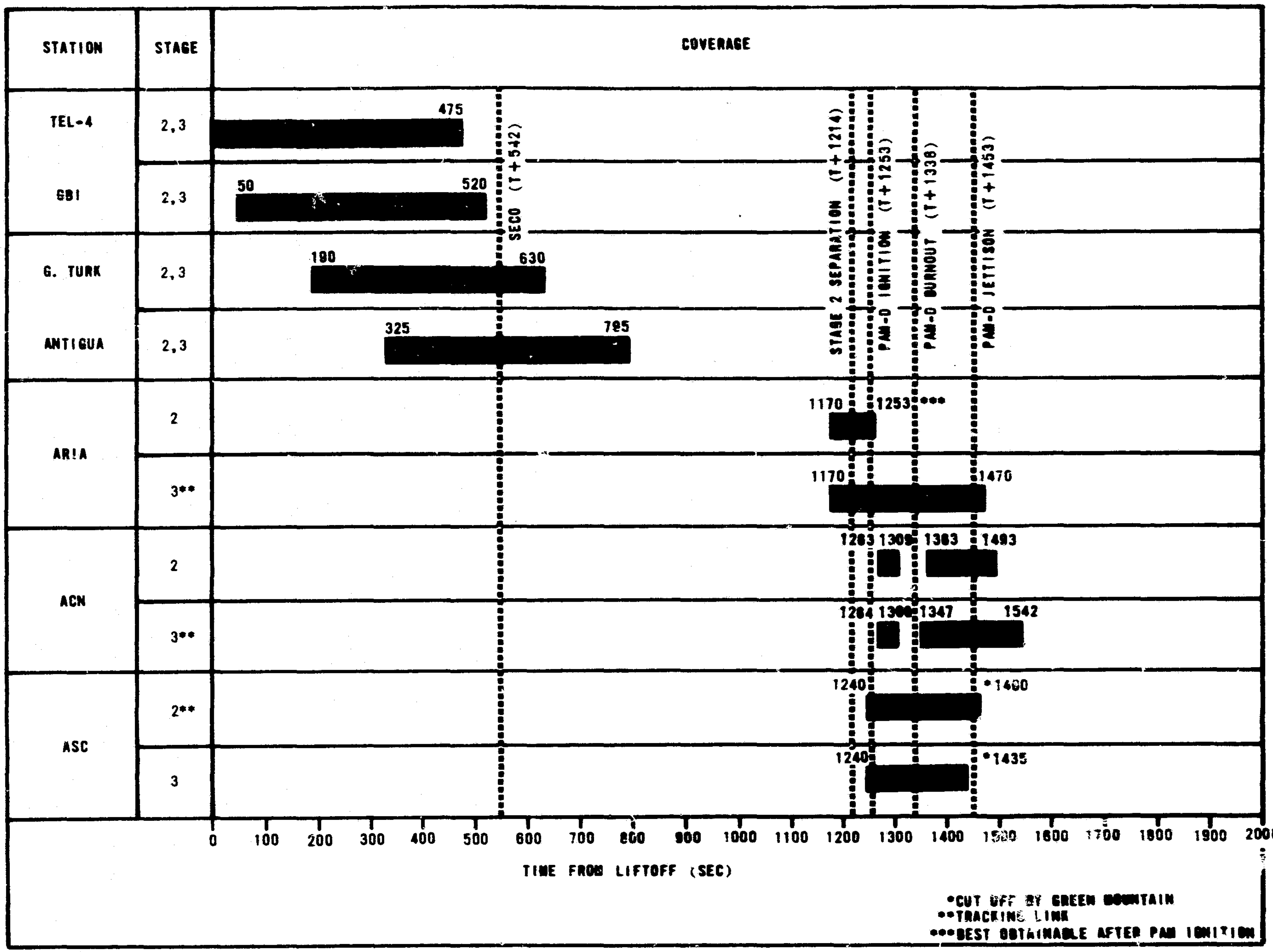


*ASC VCOS VIA HF WILL BE RECEIVED AT MULTIPLE SITES, SENT TO TEL-4, AND TEL-4 WILL SEND BEST SOURCE TO CIF.

**ARIA VCOS AND 2.4 Kbit DATA WILL BE SIMILARLY TREATED.

ORIGINAL PAGE IS OF POOR QUALITY

SBS-A VEHICLE TELEMETRY COVERAGE



SBS-A SELECTED TRAJECTORY INFORMATION

Parameter	Max Dynamic Pressure	Jettison Last Solid Motor	MECO	Stage I/II Sep	SECO	PAM Stage Ignition	Jettison PAM Stage
Time (sec)	54.690	127.500	223.900	231.900	342.812	1252.858	1452.858
Surface Range (nm)	1.90	36.872	201.207	222.924	1187.905	3766.238	4727.221
Altitude (nm)	4.81	24.851	61.610	65.450	140.679	109.251	101.241
Inertial Velocity (ft/sec)	2456.615	7881.871	18,360.947	18,372.681	24,377.747	24,604.456	33,695.206
Thrust (lb)	617,777.74	229,635.73	214,647.84	0.00	7948.91	12,039.12	0.00
Vehicle Weight (lb)	277,824.52	106,557.06	32,714.69	20,756.05	9704.96	7167.52	2387.77
Vehicle Axial Accel (ft/sec^2)	59.1102	68.5884	211.1001	0.00	0.00	54.0420	0.00
Dynamic Pressure (lb/ft^2)	969.30	72.37	0.01	0.01	0.00	0.00	0.00

SBS-A SEQUENCE OF EVENTS

T+Sec	Min:Sec	Event
T-0.2		Solid motor ignition (1,2,3,4,8)
T+0.0	00:00.0	Liftoff
		Begin open loop guidance
T+2.0	00:02.0	Begin first yaw program
T+3.0	00:03.0	Stop first yaw program
		Begin first pitch program
		Begin first roll program
T+10.0	00:10.0	Begin second pitch program
		Begin second roll program
T+12.0	00:12.0	Begin third pitch program
T+12.5	00:12.5	Begin forth pitch program
T+13.0	00:13.0	Roll gain change
T+18.0	00:18.0	Begin fifth pitch program
T+30.0	00:30.0	Begin sixth pitch program
T+37.0	00:37.0	Begin seventh pitch program
		Begin second yaw program
		Begin third roll program
T+40.0	00:40.0	Roll gain change
T+44.0	00:44.0	Begin eighth pitch program
T+55.5	00:55.5	Pitch and yaw gain change
T+57.2	00:57.2	Solid motor burn out (1,2,3,4,8)
T+57.5	00:57.5	Begin ninth pitch program
		Stop second yaw program
		Stop third roll program
T+60.0	01:00.0	Begin third yaw program
T+62.0	01:02.0	Stop third yaw program
T+64.0	01:04.0	Solid motor ignition (5,6,7,9)
		Solid motor separation (1,2,3)
		Begin tenth pitch program
		Pitch and yaw gain change
T+65.0	01:05.0	Solid motor separation (4,8)
T+70.0	01:10.0	Begin eleventh pitch program
T+78.0	01:18.0	Begin twelvth pitch program
T+80.0	01:20.0	Pitch and yaw gain change
T+90.0	01:30.0	Begin thirteenth pitch program

T+Sec	Min:Sec	Event
T+100.0	01:40.0	Begin fourteenth pitch program
		Roll gain change
T+110.0	01:50.0	Begin fifteenth pitch program
T+120.0	02:00.0	Begin sixteenth pitch program
T+121.4	02:01.4	Solid motor burnout
T+127.5	02:07.5	Solid motor separation (5,6,7,9)
		Pitch and yaw gain change
T+130.0	02:10.0	Begin seventeenth pitch program
T+135.0	02:15.0	Start guidance
T+203.9	03:23.9	Switch to velocity steering
T+213.9	03:33.9	Stop first stage closed loop guidance
T+218.9	03:38.9	Switch to acceleration only steering
T+223.9	03:43.9	MECO
		VE enable/main engine lockout
		Stage II hydraulic pump on (backup)
		Arm stage II ign and pyro pwr
T+225.9	03:45.9	Pressurize tanks
T+229.9	03:49.9	VECO
T+231.9	03:51.9	Blow stage I/II separation bolts
T+236.9	03:56.9	Start stage II engine
T+240.0	04:00.0	Fairing unlatch
T+241.0	04:01.0	Fairing separation
T+242.0	04:02.0	Begin eighteenth pitch program
T+252.0	04:12.0	Begin nineteenth pitch program
T+270.0	04:30.0	Start guidance
T+492.8	08:12.8	Switch to velocity steering
T+539.8	08:59.8	Switch to acceleration only steering
T+541.6	09:01.6	Stop guidance
T+542.6	09:02.6	SECO
		Disarm stage II ign and pyro pwr
		Turn off hydraulic pump
T+600.0	10:00.0	Begin twentieth pitch program
T+603.8	10:03.8	Turn off CDRs
T+705.0	11:45.0	Begin fourth yaw program
T+805.0	13:25.0	Stop fourth yaw program

T+Sec	Min:Sec	Event
T+1150.0	19:10.0	Begin first coast guidance
T+1200.0	20:00.0	Stop first coast guidance
T+1211.9	20:11.9	Arm stage II ign & pyro pwr
T+1212.9	20:12.9	Fire spin rockets
		Start stage III ign pyro time delay
		Start payload sep pyro time delay
T+1213.9	20:13.9	Fire stage III wire cutters

T+Sec	Min:Sec	Event
T+1214.9	20:14.9	Blow stage II/III sep bolts
T+1216.9	20:16.9	Disarm stage II ign and pyro pwr
T+1252.9	20:52.9	PAM stage ignition
T+1338.6	22:18.6	PAM stage burnout
T+1452.9	24:12.9	Payload separation
T+1454.9	24:14.9	Release YO weight